

Value Engineering on Bias Munjul Port Project in Nusa Ceningan Bali Indonesia

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Abstract— In the implementation of a project, many problems can be found that can waste the costs. The construction of the Bias Munjul Port in Nusa Ceningan went through re-design due to a request from the Minister of Transportation and the Governor of Bali because the design did not meet the Bali Provincial Regulation Number 5 of 2005 about Architectural Requirements for Buildings. It cost IDR 110,837,794,000.00 or more than 11.32% of the contract price IDR 98,292,823,000.00. It means that the price of construction has increased which exceeds the maximum limit for adding to the contract price based on Presidential Regulation Number 16 of 2018 which is 10% of the initial contract price. Therefore, it is necessary to do cost-effectiveness; a method that can be used to make costs efficient without reducing the value of the function is the Value Engineering method, a quantitative method. The steps taken in this research are: Information Phase, Functional Analysis Phase, Creative Phase, Evaluation Phase, Presentation Stage. In the first phase, the cost of the works is included in the budget plan using Pareto diagram. The results showed that the savings cost on the ro-ro dock was 6% of the initial plan using a pile foundation with a depth of 47 m. The dredging works obtained a 17% savings from the original plan using a dredging width of 100 m and a depth of -3.7 m. On architectural work, 81% savings from the original plan were obtained using batu candi. The total saving for all of these works was IDR 5,944,671,890.80 or 5.89% from the initial plan.

Keywords— Value Engineering, Port Project, Cost Efficiency, Project Implementation Methods

I. INTRODUCTION

The construction of large scale projects needs effective management. One method of completion as well as planning and controlling a project is construction management. Bias Munjul Port Construction Project in Nusa Ceningan is a project that requires various resources and various activities with a high risk of mobilizing tools and also materials. Therefore, detailed planning needs to be done. Project goals must be achieved according to the schedule plan, so it is important to control all the resources against changes in costs to cut expenses as much as possible.

Cost savings are possible by avoiding certain project methods used by comparing project design with project implementation.

In the way it works, the budget that is used as a design guide, and the standards that must be met are problems that often arise. The total project cost is strongly influenced by the project budget. Several factors, such as the quality of work, the number of workers on the project, the time it takes to complete the task have a big impact on expenses in various divisions of work.

The re-analysis focuses on specific aspects of the work process and significant expenditures in an effort to uncover savings. This leads to studies that, instead of correcting

errors or calculations that the planner may have made, lead to more effective engineering choices and cost savings.

The three main factors related to implementation are time, method, and cost.

II. MATERIALS AND METHODOLOGY

2.1 STUDY AREA

The location of this research is the Bias Munjul Port Construction Project in Nusa Ceningan, which is located in Klungkung Regency, Bali Province. The construction of the Munjul Bias Port in Nusa Ceningan underwent a design change due to a request from the Minister of Transportation and the Governor of Bali because the initial design was deemed not to comply with the Bali Provincial Regulation Number 5 of 2005 about Building Architectural Requirements, this building consists of two floors and its implementation requires a cost of 110,837,794,000.00 IDR or more than 11.32% of the initial contract value of 98,292,823.000.00 IDR. This means that the value of development after the *re-design* has increased significantly and exceeded the maximum limit for adding to the contract value based on Presidential Regulation Number 16 of 2018 which is 10% of the initial contract value. Therefore, it is necessary to study the cost-effectiveness using the value engineering method with the aim of reducing project costs without reducing the planned quality.

2.2 DATA COLLECTION METHOD

The research method used is quantitative, which is a process of finding knowledge by collecting data in the form of numbers as a tool to analyze information about what is known; this research method translates data into numbers to analyze the findings. Each stage is a part that is used to carry out the next stage. The existing theory is the basis for conducting research studies and refers to the background and objectives to be achieved.

2.3 DATA TYPE

Secondary data are a type of study information obtained by researchers through intermediary sources (obtained and recorded by other parties). Secondary data are additional information that can be used as a source of information and as a guide in conducting value engineering studies (Mulyono and Iskandar, 2016). Drawings of the initial plan, RKS, and RAB are secondary data. Primary data are information collected through fieldwork using an observational approach.

2.4 VALUE ENGINEERING PHASE

2.4.1 Information Phase

The information stage is the first stage of implementing the value engineering, trying to find all information about work items that can be studied (Permata, 2016). The information phase is the time when most of the project-related data are collected. The value engineering team seeks knowledge of the role of each component in the process (Bertolini, 2016). All information is obtained by asking the project team directly or by *surveys*. Applying Pareto's Law of Distribution is helpful when beginning to look for potential savings. Pareto's Law states that 80% of a project's cost will be in 20% of the work. Preparing a project cost model will begin to identify targets of opportunity.

The following are the steps in Pareto's law:

1. Sorting work item from largest to smallest
2. Summing the total work costs cumulatively
3. Calculating the percentage of the cost of each work item

$$\% \text{ Cost Work} = \frac{\text{Cost Work}}{\text{Total Cost Work}}$$

4. Calculate cumulative percentage
5. Plot cumulative percentage

2.4.2 Function Analysis Phase

The function analysis phase is important because it makes the value engineering method different from other cost-effectiveness strategies. The defined information phase defines the functionality of the project components at this point. In this step, the expected cost after applying value engineering is calculated together with the available value of a subsystem. The Function Analysis System Technique (FAST) diagram is a tool that can be used during the function analysis phase. The tool used to test product functions, both secondary and primary functions, is the Function Analysis System Technique (FAST) diagram. Diagrams created using FAST are used to determine areas that need to be developed. These improvements can lead to innovation, a process that can encourage the emergence of original ideas.

2.4.3 Creative Phase

Investigation is followed by the creative phase, which is where the value and effectiveness of the value engineering technique are realized. To come up with workable alternatives to the project's current design, the team uses brainstorming approaches. People are forced to be imaginative when brainstorming. This effect is caused by a process known as synergism, in which one idea or concept

stimulates others through comparable or related ideas, contiguous or adjacent ideas, opposing or contrasting ideas, and sound-alike ideas.

2.4.4 Evaluation Phase

During the Evaluation Phase, the advantages and disadvantages of each remaining alternative are listed. Each advantage and disadvantage is described in general terms. The team can perform a weighted matrix analysis to determine which alternative is best based upon the relative importance of each of the desirable criteria which must be addressed. Of course, if the disadvantages are found to far outweigh the advantages of any alternative, the alternative is dropped from further consideration at this point.

2.4.5 Presentation Phase

The formal report and the presentation of the team's suggestions are the results of value engineering research. The value engineering team tries to persuade the project decision-makers to adopt their suggestions during this phase when they submit their findings to them.

This formal presentation should be succinct yet thorough, and there should be enough time for questions and discussion. The study team should take care when providing predicted cost reductions or, in some situations, higher expenses connected with suggestions when making the presentation. It is best to refrain from overstating or double counting funds. It is advantageous for the study team to send progress updates to the relevant project management staff for value engineering studies that take longer to complete.

The work completed throughout the earlier phases is meticulously documented in the value engineering Report. The report chronicles the team's discussions and considerations, offers evidence to back up the team's recommendations, and assists in putting the suggestions into practice. It might also be a helpful resource for future projects and studies on value engineering that need to address related issues.

III. RESULT AND DISCUSSION

3.1 INFORMATION PHASE

The information stage, the first step in value engineering *g*, seeks to gather information about the work items to be assessed (Permata, 2016). The data collected can be in the form of primary data and secondary data. This research was at the Bias Munjul Port Construction Project in Nusa Ceningan. When value engineering method was applied, the work in the field had reached 10.22% with dredging work items.

3.1.1 Pareto Analysis

At the information stage, the first thing that will be done is an analysis using a Pareto diagram; the principle of this method is that 80% of the highest total costs are 20% of work items.

Table 1. Cost Rank

Description	Cost	Frequency	Cummulative
	(Rp)	%	%
Ro/Ro Dock	29.198.980.527,27	28,98	28,98
Dredging & Harbor Pool	28.114.315.822,26	27,90	56,88
Structure	11.303.576.098,53	11,22	68,10
Architecture	9.481.159.692,83	9,41	77,51
Revetment	6.218.434.501,34	6,17	83,68
Preparation	4.085.540.986,92	4,05	87,73
Floating Dock	3.669.500.005,80	3,68	91,41
Mechanical & Electrical	3.709.048.409,00	3,64	95,06
Parking Area	1.606.309.856,05	1,59	96,65
Plumbing	1.378.633.597,11	1,37	98,02
Power House, Signage & Pump House	547.460.890,26	0,97	98,99
Pelinggih	470.921.399,25	0,54	99,53
Fence	977.749.900,73	0,47	100
Cost	100.761.631.687,35	100,00	
Tax 10%	10.076.163.168,74		
Total	110.837.794.856,09		
Rounding	110.837.794.000,00		

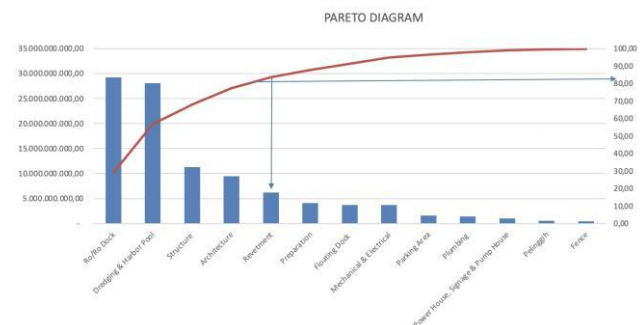


Fig.1. Pareto Diagram

Based on Figure 1 above, the items carried out by value engineering can be described as follows: Ro/Ro Dock, Dredging & Harbor Pool, Structure, Architecture, Revetment. However, in this study, structure and revetment work will not be analyzed by value engineering because the design and specifications have been determined by the owner and, according to experts, the existing design is optimal.

Table 2. Value Engineering Work

Description	Cost
	(Rp)
Ro/Ro Dock	29.198.980.527,27
Dredging & Harbor Pool	28.114.315.822,26
Architecture	9.481.159.692,83
Cost	84.316.466.642,23
Tax 10%	66.794.456.042,36
Total	6.679.445.604,24
Rounding	73.473.901.646,60

3.1.2 Determination of Criteria

In the selection of alternative substitute materials, there are several criteria to determine the choice, such as costs, quality and durability, aesthetics, duration, and obtaining materials. To find out the importance of these criteria in value engineering, the weight of each criterion will be calculated using the Analytical Hierarchy Process (AHP) method.

To fill in the paired matrix, by using numbers to represent the relative importance of one element to the other elements referred to in the form of a scale from 1 to 9. This scale defines and explains the value of 1 to 9 for consideration in pairwise comparisons of elements at each level of the hierarchy to a criterion at a higher level. If an element is in the matrix and compared to itself, then it is given a value of 1. If *i* compared to *j* gets a certain value, then *j* compared to *i* is the opposite. The paired matrix of the existing criteria can be seen in Table 3. following.

Table 3. Paired Matrix

Criteria	Cost	Quality & Durability	Aesthetics	Duration	Obtaining Material
Cost	1	2	4	3	3
Quality & Durability	0,5	1	4	2	3
Aesthetics	0,25	0,25	1	0,5	2
Duration	0,33	0,5	2	1	3
Obtaining Material	0,33	0,33	0,5	0,33	1
Total	2,42	4,08	11,50	6,83	12,00

Results of the paired matrix calculation are the weights of each criterion, which are presented in Table 4 below.

Table 4. Result of Paired Matrix

Criteria	Cost	Quality & Durability	Aesthetics	Duration	Obtaining Material	Total	Weight
Cost	0,414	0,490	0,348	0,439	0,250	1,940	38,809
Quality & Durability	0,207	0,245	0,348	0,293	0,250	1,342	26,846
Aesthetics	0,103	0,061	0,087	0,073	0,167	0,491	9,829
Duration	0,138	0,122	0,174	0,146	0,250	0,831	16,613
Obtaining	0,138	0,082	0,043	0,049	0,083	0,395	7,903
Total	1	1	1	1	1	5	100

In Table 4 above, the weight of each criterion is obtained, namely:

1. Construction Cost = 38,809
2. Quality and Durability = 26,846
3. Aesthetics = 9.83
4. Implementation Time = 16.16
5. Ease of Obtaining Materials = 7.9

The weights above will later be used in making alternative choices for each material by multiplying by the number of scores obtained.

3.2 EVALUATION OF RO-RO DOCK WORK

The Ro-Ro dock work is value engineering's first project. The length of the dock, the width, the depth of the harbor pool, and the land required to support the operation are used to calculate the size of the port. The amount of investment required will depend on the size and style of the dock building, which is functional and efficient. To fit the demand for port services and the available capacity for certain services, investments are made in the development and addition of port facilities and infrastructure.

From the DED drawing of the Ro-Ro pier, the construction of the pier is planned to accommodate ships with a capacity of 300 GT to 700 GT, using a pile foundation of SPP 609 t=12 with a pole length of 52 m with three connections, so the cost is quite expensive. Regarding this, for investment cost efficiency an evaluation of the length of the pile can be done, taking into account the friction factor and the results of the Standard Penetration Test at a depth of 47 m: the Standard Penetration Test value has reached 50 ($N > 50$ = Hard Soil; $15 < N < 50$ = Medium Soil, $N < 15$ = Soft Soil).

After evaluating and calculating the ranking results by looking at construction costs, quality and durability, aesthetics, implementation time and ease of obtaining materials, a saving of 6% was obtained from the existing design in the form of a 52 m deep pile foundation to 47 m which is presented in Table 5 below.

Table 5. Evaluation Ro-Ro Dock Work

			Existing	Alternative 1
Num	Freq	Comparison Subject	Pile Foundation 52 m	Pile Foundation 47 m
Total Cost (Rp)			29.198.980.527	27.501.343.524
Life Cycle Cost (Rp)			240.716.395.467	226.721.076.008
Saving (Rp)			-	13.995.319.459
Percentage Saving			-	-6%
1	38,8%	Construction Cost	2	3
2	26,8%	Quality & Durability	3	3
3	9,8%	Aesthetics	3	3
4	16,6%	Duration	2	3
5	7,9%	Obtaining Material	2	2
Total Frequency			2,37	2,92
Ranking			2	1

3.3 EVALUATION OF DREDGING & HARBOR POOL WORK

The next work carried out by value engineering is dredging and harbor pool work. This work has a big percentage compared to the other work on bill of quantity. In this work, the dredging cross-sectional width is 100 m with a depth of – 4 m and a slope of 1:2 sloof.

After evaluating and calculating the ranking results by looking at construction costs, quality and durability,

aesthetics, duration and obtaining materials, savings of 17% were obtained from the existing design in the form of dredging width > 100 m and depth of -4 m to dredging width of 100 m and depth -3.7 m which is presented in Table 6 below.

Table 6. Evaluation Dredging and Harbor Pool Work

Num	Freq	Comparison Subject	Existing	Alternative 1	Alternative 2
			Dredging Width > 100m and depth of -4 m	Dredging Width >100m and depth of -3,7m	Dredging Width 100m and depth of -3,7m
		Total Cost (Rp)	28.144.315.822,26	25.810.087.933,28	24.119.142.647
		Life Cycle Cost (Rp)	232.021.739.639	212.778.364.922	198.838.211.983
		Saving (Rp)	-	19.243.374.717	33.183.527.665
		Percentage Saving	-	-9%	-17%
1	38,8%	Construction Cost	1	2	3
2	26,8%	Quality & Durability	3	2	2
3	9,8%	Aesthetics	3	3	3
4	16,6%	Duration	1	2	3
5	7,9%	Obtaining Material	2	2	2
		Total Frequency	1,81	2,10	2,65
		Rangking	3	2	1

3.4 EVALUATION OF ARCHITECTURAL WORK

The next item included in Pareto analysis is architectural work. There are many additional items to the architectural work after re-design, this is in accordance with the Bali Regional Regulation No. 5 of 2005 concerning the architectural requirements of the building. The materials chosen as the existing design have high cost.

After evaluating and calculating the ranking results by looking at construction costs, quality and durability, aesthetics, duration and obtaining materials, savings of 81% were obtained from the existing design in the form of a pair of black stone from Karangasem to a temple stone pair, which is presented in Table 7 below .

Table 7. Evaluation Architectural Work

Num	Freq	Comparison Subject	Existing	Alternative 1	Alternative 2
			Black Stone Karangasem	Temple Stone	Black Andesite Stone
		Total Cost (Rp)	561.351.552	309.489.839	344.073.863
		Life Cycle Cost (Rp)	4.627.782.197	2.551.434.233	2.836.544.929
		Saving (Rp)	-	2.076.347.964	1.791.237.268
		Percentage Saving	-	81%	63%
1	38,8%	Construction Cost	2	3	3
2	26,8%	Quality & Durability	3	3	2
3	9,8%	Aesthetics	3	3	3
4	16,6%	Duration	3	3	3
5	7,9%	Obtaining Material	2	2	2
		Total Frequency	2,53	2,92	2,65
		Rangking	3	1	2

3.5 PRESENTATION PHASE

The presentation stage is the last stage of value engineering. At this stage, the previously processed data

will be presented to the owner. The combination of all the alternatives described in the previous stage can be seen in Table 8 below.

Table 8. Presentation Table

Num	Existing	Alternatif 1	Alternatif 2
A	Ro-Ro Dock		
	Pile Foundation 52 m	Pile Foundation 47m	-
	29.198.980.527	25.510.343.524	-
B	Dredging and Harbor Pool		
	Dredging Width > 100m and depth of - 4 m	Dredging Width >100m and depth of -3,7m	Dredging Width 100 and depth of -3,7m
	28.144.315.822	25.810.087.933	24.119.152.647
C	Architectural		
	Black Stone Karangasem 561.351.552	Temple Stone 309.489.839	Black Andesite Stone 344.073.863

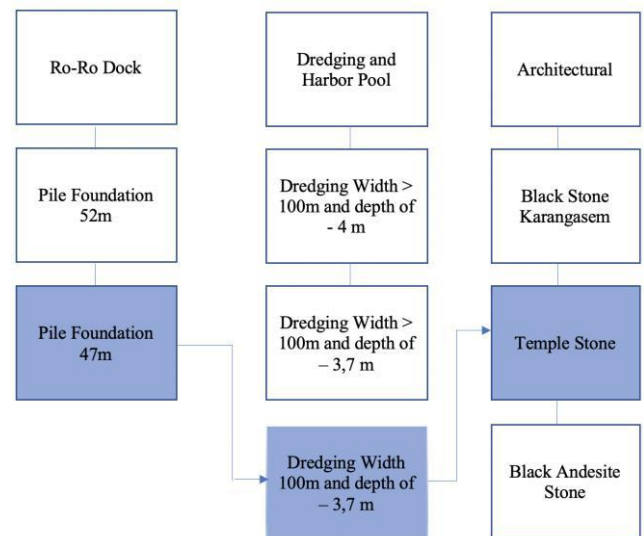


Fig.2. Combination of Alternatives

From Figure 2. it can be seen that the alternatives chosen after doing value engineering are pile foundations with a depth of 47 m on Ro-Ro Dock Work, Dredging with a width of 100 m and a depth of 3.7 m on Dredging and Harbor Pool Work and Temple Stone in Architectural Work.

IV. CONCLUSION

From the results of the research done, it can be concluded as follows:

1. There are five work items that are analyzed by value engineering, which consist of Dredging Work for Channels and Port Ponds, Ro-Ro Pier Works, Structural Works, Architectural Works and *Revetment* and DPT. However, due to a request from the owner and with the approval of the Construction Management in the case of Structural Experts for Structural Works and *Revetment* and DPT, no changes need to be made.
2. The selected alternatives are:

- a. Ro-Ro Pier work from the initial design using pile foundation with a depth of 52m replaced with a depth of 47m.
 - b. The dredging of the harbor channel and pond from the initial design using a width of >100 m and a depth of -4 m, was changed to a width of 100 m and a depth of 3.7 m.
 - c. Architectural work from the initial design using Karangasem black stone masonry replaced with temple stone masonry.
3. Cost savings after value engineering is Rp. 5,944,671,890.80 or 5.89% of the initial RAB value of Rp. 110,837,794,000.00 (Includes VAT).

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